Preface

The field of organ transplantation has undergone remarkable changes in the last decade. The growing numbers of agents available for immunosuppression have played a significant role in the advancement of this field. However, just as important has been the development of surgical innovations in the field. This includes not only the development of new surgical procedures, but also modifications of the existing ones. This has involved all areas of organ transplantation including deceased-donor procurement techniques, living-donor transplantation, and transplantation of the individual organs including kidney, liver, pancreas, and intestine. Examples include procurement from non–heart-beating donors; living-donor transplants involving the liver, pancreas, or intestine; laparoscopic donor nephrectomy; split-liver transplants; and multivisceral transplants. All of these represent new, innovative procedures that are being performed on a regular basis only in the last few years. Given these recent dramatic changes in the surgical face of transplantation, we felt it was time for a surgical atlas of transplantation that highlighted these recent developments.

The aim of this book is to provide the reader with a comprehensive, pictorial step-by-step account of abdominal organ transplant procedures performed by contemporary transplant surgeons. Emphasis has been placed on newer procedures or procedures that have undergone significant modifications. It is recognized that there are many well-accepted techniques for the same procedure, with each having potential merit. While it is impossible to present all of these variations, an attempt has been made to describe the common variations in surgical technique.

Innovations in imaging have allowed us to organize this atlas in a format that provides the reader with the most clear and realistic view of the operative procedures. Schematic diagrams are included to complement high-quality intraoperative photographs, allowing readers to clearly visualize the course of the operative procedure. A unique feature of this atlas is a digital video file of the major operative procedures, which provides the reader with the closest possible experience to being present in the operating suite. It is hoped that this format will provide the reader with a clear visual and written description of all major abdominal transplant procedures performed by the modern transplant surgeon.

2

Dialysis Access Procedures

Khalid O. Khwaja

Hemodialysis

Introduction

Hemodialysis is one of the main modalities for renal replacement therapy in patients with end-stage renal disease. Successful hemodialysis is contingent upon the creation of proper vascular access. Chronic vascular access was first established in 1960 by Scribner and colleagues when they created a shunt between the radial artery and the cephalic vein using an external Silastic device. However, this device was fraught with problems such as bleeding, clotting, and infection. In 1966, Breschia and Cimino described a surgical fistula between the radial artery and the cephalic vein just proximal to the wrist, thereby eliminating the external shunt and enabling a high flow system for hemodialysis. To this day, it remains the procedure of choice for patients with end-stage renal disease in need of chronic hemodialysis.

Several principles should be followed when planning vascular access surgery. In general, primary fistulas are better than prosthetic grafts due to better long-term patency and lower risk of infection and thrombosis. The upper extremity is preferable to the lower extremity and the nondominant arm should be employed first. If possible, a distal site should be selected first, preserving the upper arm for subsequent use. Careful preoperative vascular assessment is performed with palpation of the radial, ulnar, and brachial pulses; an Allen's test is performed on both sides. The superficial veins of the arm should be carefully assessed with application of a proximal tourniquet. In some cases, the cephalic vein is readily evident at the wrist, antecubital fossa area, or in the lateral aspect of the upper arm. Once a decision has been made to perform access surgery, no venipunctures or blood pressure monitoring should be performed in that arm. If no superficial veins are apparent, the venous system may be assessed by ultrasound examination of the arm. Both the cephalic and basilic systems are interrogated, as well as the deep venous system and the central veins. Patients with suspected central venous stenosis or prior catheters inserted on the ipsilateral side, or with abnormal findings on ultrasound, may be assessed by conventional venography. If central stenoses are found, they should be corrected by endovascular techniques preoperatively, or an alternate site for access should be sought.

Vascular access should be established prior to the actual need for hemodialysis, thereby avoiding temporary external catheters, which have a higher risk of infection and are also associated with central venous stenosis. This chapter discusses the technique for some common permanent access procedures.

Surgical Procedures

a) Radiocephalic Fistula

The radiocephalic fistula, as described by Breschia and Cimino, is the procedure of choice. A suitable cephalic vein just proximal to the wrist is identified preoperatively and a negative Allen's test confirmed. Although up to a third of these fistulas fail to mature, the long-term patency is excellent with as many as half of them still functioning 5 to 10 years after creation.

1. The whole arm, including the axilla, is prepped and draped. As no prosthetic device is being employed, antibiotics are not a requisite. A vertical incision is fashioned just proximal to the flexion crease of the wrist between the radial artery and the cephalic vein (black arrow). Some surgeons prefer to make an incision over the anatomic snuff box more distally and use the deep branch of the radial artery to create the fistula (grey arrow) (Figure 2.1).

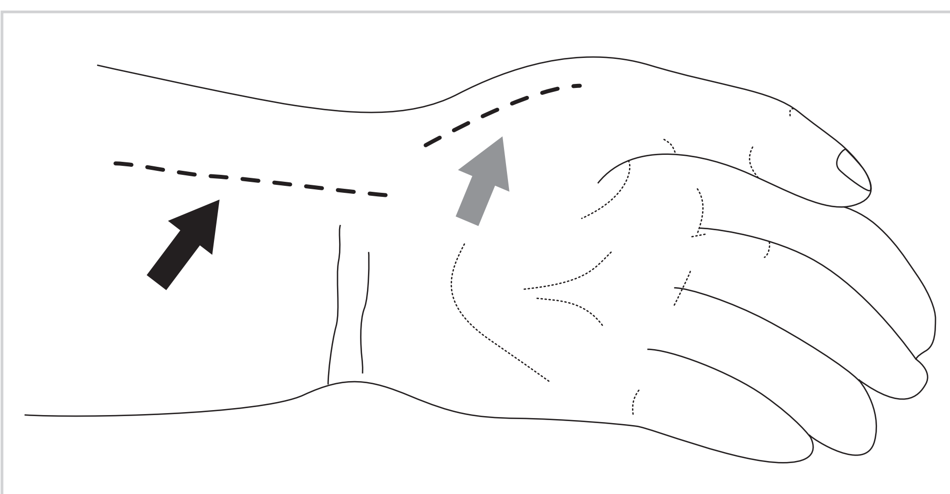


Figure 2.1

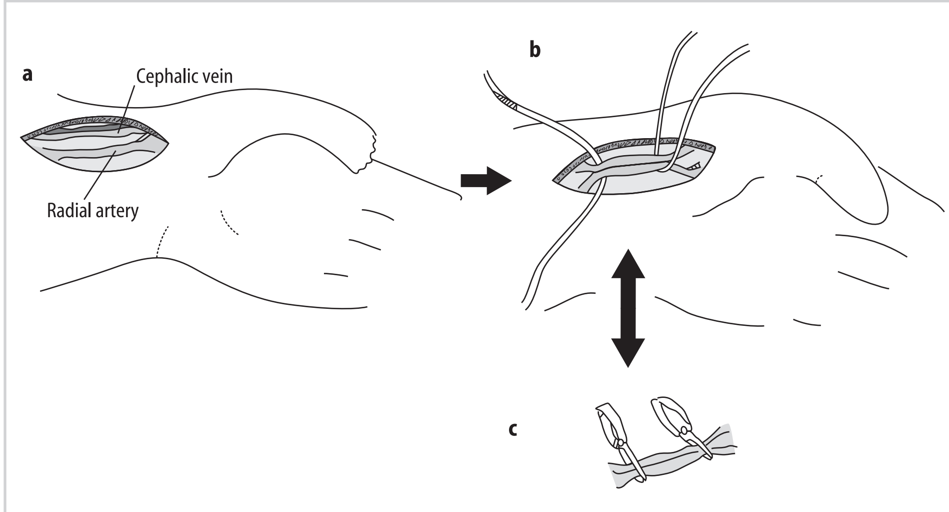


Figure 2.2

2. The incision is carried through the subcutaneous tissue, and then medial and lateral flaps are raised. Both the cephalic vein and radial artery are very superficially located and can readily be exposed (Figure 2.2a). The cephalic vein is mobilized as far proximally and distally as possible and any large branches ligated. The radial artery is also mobilized for a short distance. Once mobilization is complete, both the cephalic vein and radial artery are placed adjacent to each other in a side-by-side fashion. This can be accomplished by placing a vessel loop proximally and distally, with each loop incorporating the artery and vein. By tightening up on the loop, the two vessels are brought together (Figure 2.2b). If necessary, systemic heparin can now be administered. Control of the vessels can be achieved by tightening up on the vessel loops or by using small vascular clamps (Figure 2.2c).

3. A corresponding venotomy and arteriotomy are made in the cephalic vein and radial artery (Figure 2.3a). The arteriotomy should be limited to 6 or 7 mm to prevent a

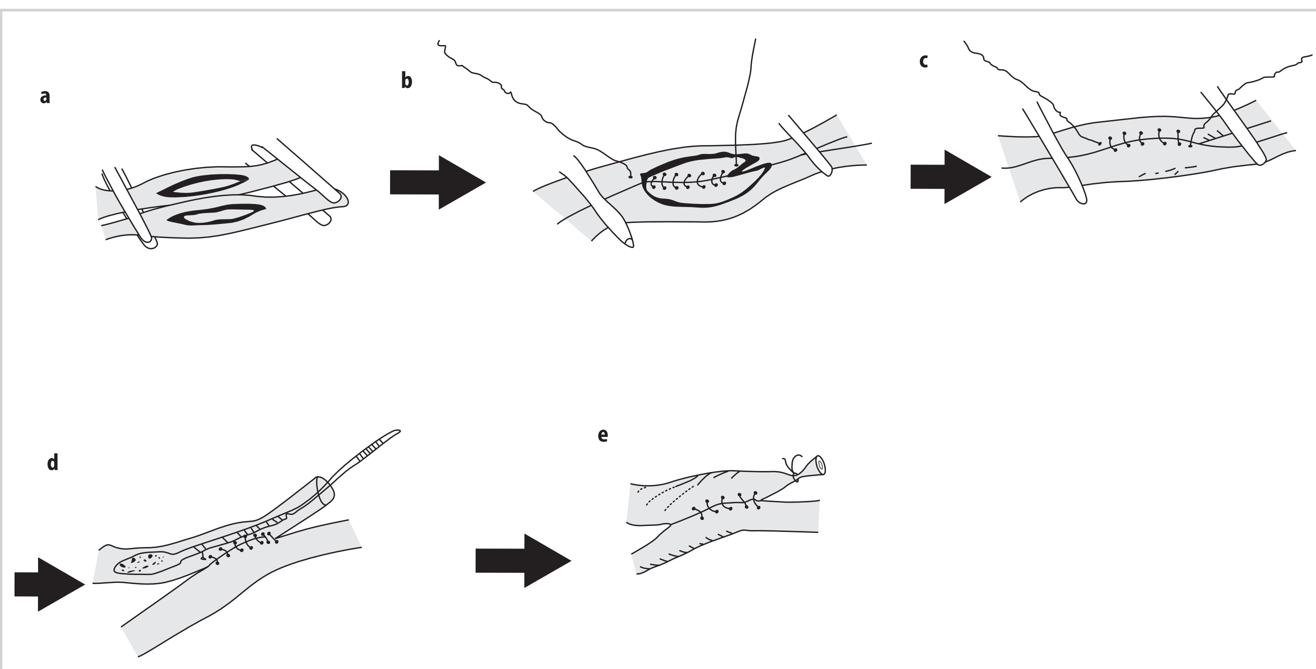


Figure 2.3

steal syndrome. A side-to-side anastomosis is then constructed using fine, nonabsorbable monofilament suture (Figures 2.3b and 2.3c). One technique is to sew the posterior wall from within the lumen, then running the suture anteriorly to complete the anastomosis. Prior to reperfusion, the anastomosis can be probed through an opening created in the distal cephalic vein (Figure 2.3d). The probe is passed sequentially up the cephalic vein and the radial artery. The distal cephalic vein is then ligated and the arterial clamps released to perfuse the fistula (Figure 2.3e).

4. Alternatively, an end-to-side or end-to-end anastomoses between the radial artery and cephalic vein can be created by dividing the vein initially (Figure 2.4a) and then anastomosing it to the artery (Figure 2.4b).

A radiocephalic fistula usually requires 8 to 12 weeks to mature. Sometimes a second procedure is required to ligate a side branch or angioplasty an area of proximal stenosis.

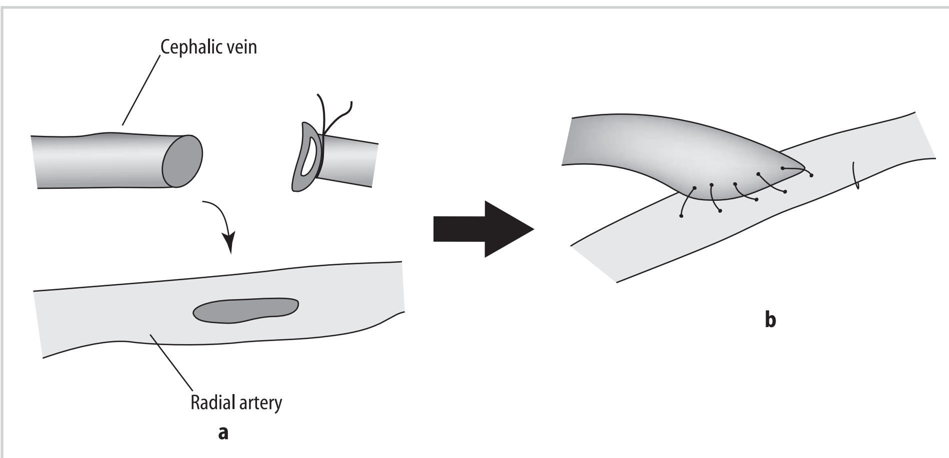


Figure 2.4

b) Brachiocephalic Fistula

If a suitable cephalic vein at the wrist is not present, then a more proximal brachiocephalic fistula may be created. In some instances, the cephalic vein might be deep in the upper arm and not clinically visible. If it is seen on ultrasound examination and has a diameter of 3 mm or more, then it may be suitable for fistula creation. Brachiocephalic fistulas have a primary failure rate of close to 10% and good long-term patency.

1. A preoperative evaluation is performed as described for the radiocephalic fistula. The whole arm is prepped from the wrist to the axilla. This procedure can be performed under local anesthetic with sedation. The elbow is examined to mark the course of the cephalic vein (red arrow) and palpated to locate the position of the brachial artery (broken red line), which lies adjacent to the basilic vein (yellow arrow) (Figure 2.5).

2. Both the brachial artery and cephalic vein can be isolated through a transverse incision either above (Figure 2.6a) or below (Figure 2.6b) the antecubital crease. The cephalic vein may require some mobilization to reach the brachial artery and may need to be dissected distally to the upper part of the forearm to gain adequate length for it to reach the artery. Frequently, an antecubital or median cubital vein (blue arrow) can be found that communicates with the cephalic vein, and this vein can be used for the

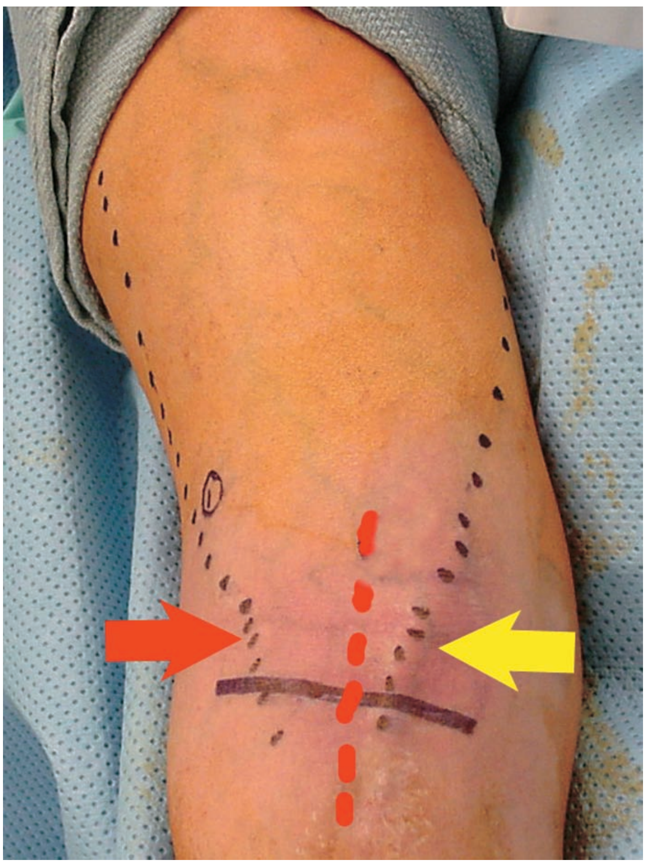


Figure 2.5

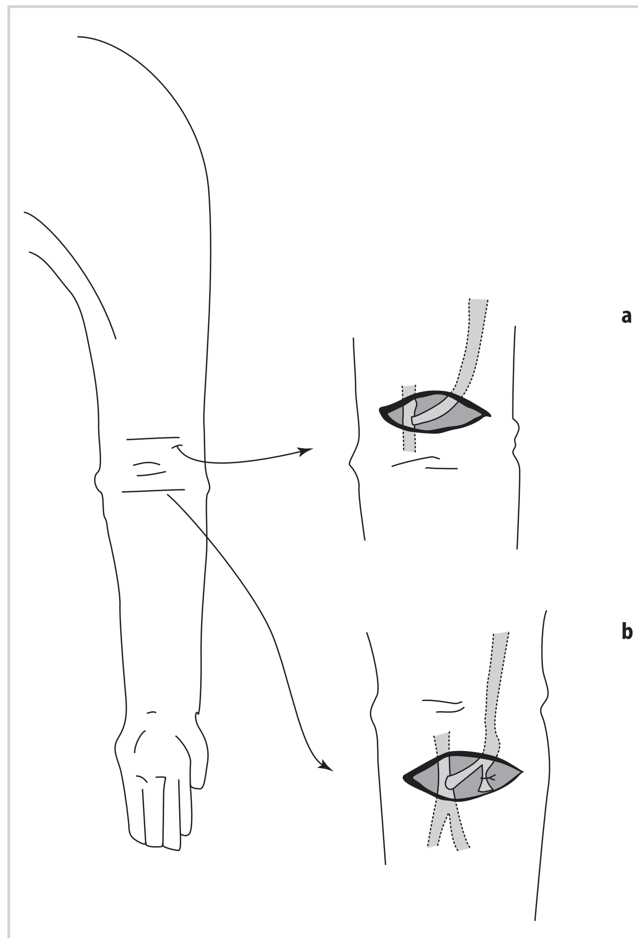


Figure 2.6

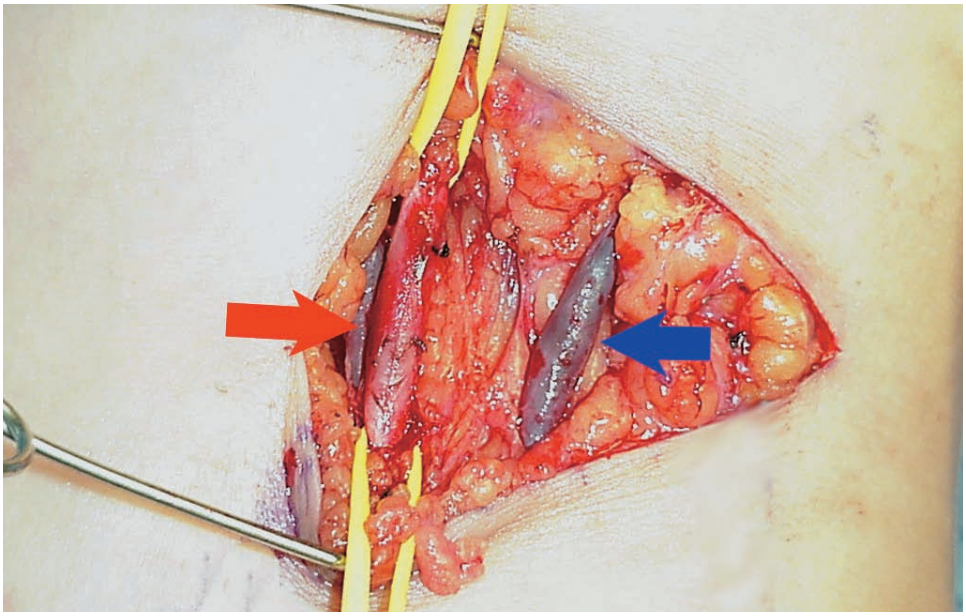


Figure 2.7

anastomosis with the distal cephalic vein being ligated (Figure 2.6b). It usually easily reaches the brachial artery (red arrow) (Figure 2.7)

3. Once an adequate length of vein is dissected free, it is divided. An end-to-side anastomosis is then constructed using fine, nonabsorbable monofilament suture (Figure 2.8). If the cephalic vein is found to be unsuitable, then the basilic vein can be used through the same approach and transposed so it runs in a more superficial course (described next). If none of these veins is suitable, a loop forearm graft can be created through the same incision. A primary brachiocephalic fistula matures in 8 to 12 weeks.

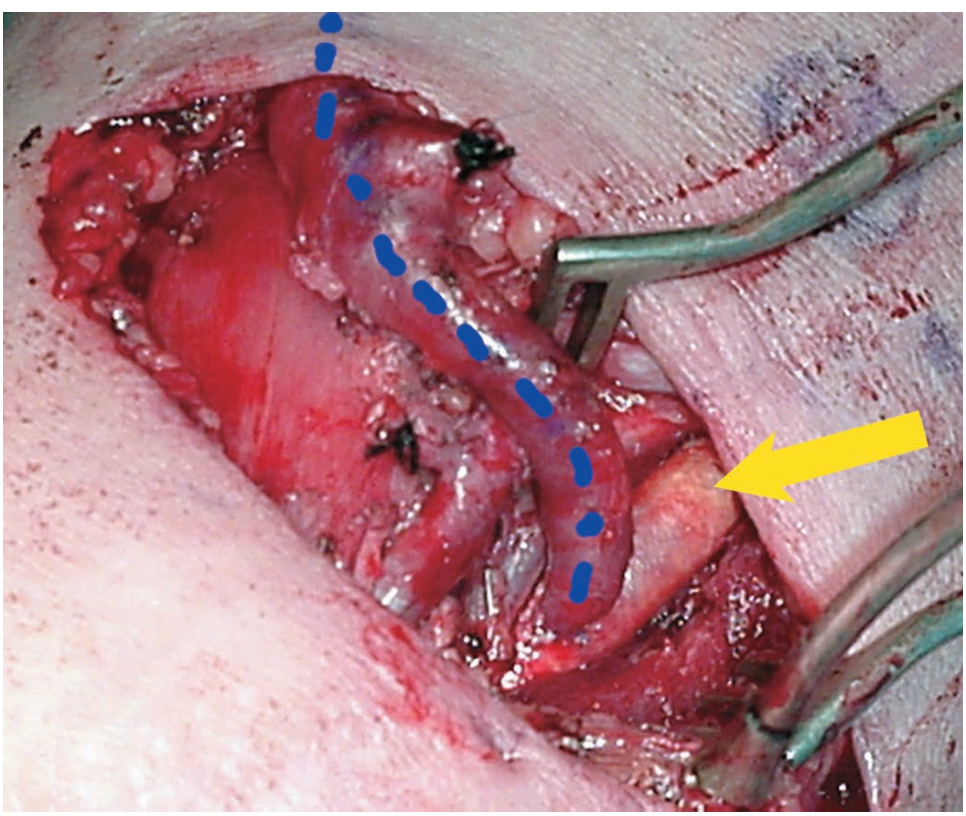


Figure 2.8

4. Sometimes the cephalic vein at the level of the elbow and above is of adequate size, but too deep to simply anastomose directly to the brachial artery. If the vein is deep, it may be difficult to cannulate for subsequent dialysis. In this case the vein can be dissected for some length above the elbow, and then brought through a tunnel created just below the skin to transpose the vein to a more superficial location. This is done by first isolating the vein either just above or below the antecubital fossa and then dissecting it further proximally as much as possible through the transverse incision. The vein is divided as far distally as possible. A longitudinal counterincision is then made higher in the arm and the same vein is isolated and mobilized into this incision (Figure 2.9). At this point it is helpful to gently dilate the vein (large blue arrow) with saline solution to ensure that there is no twisting. The vein can be marked with a pen to maintain this orientation. One is now ready to create the superficial tunnel for the vein (small blue arrows).

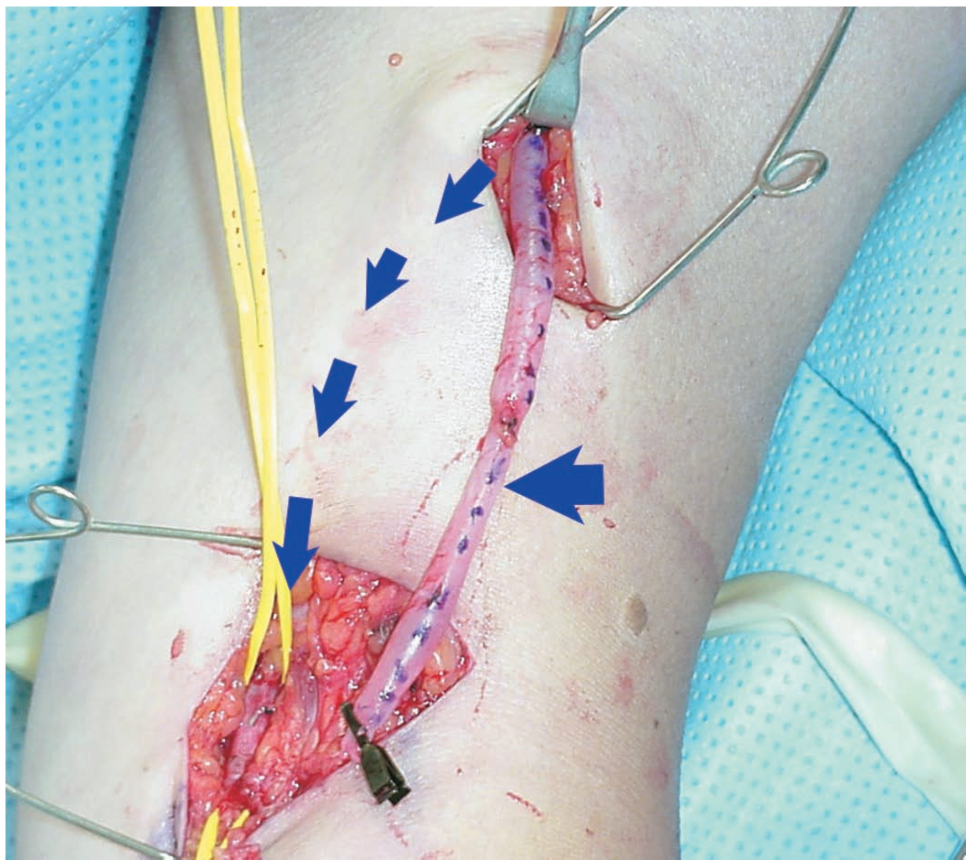


Figure 2.9

Figure 2.10

5. A subcutaneous tunnel is created for the vein using a tunneler or other blunt instrument (Figure 2.10). The tunnel should start just above the brachial artery and end at the proximal extent of the upper arm incision.

6. The cephalic vein is brought through the tunnel, making sure that the vein does not twist as it is being pulled through. The end of the vein (blue arrow) is positioned just above the brachial artery (yellow arrow), in preparation for the anastomosis (Figure 2.11).

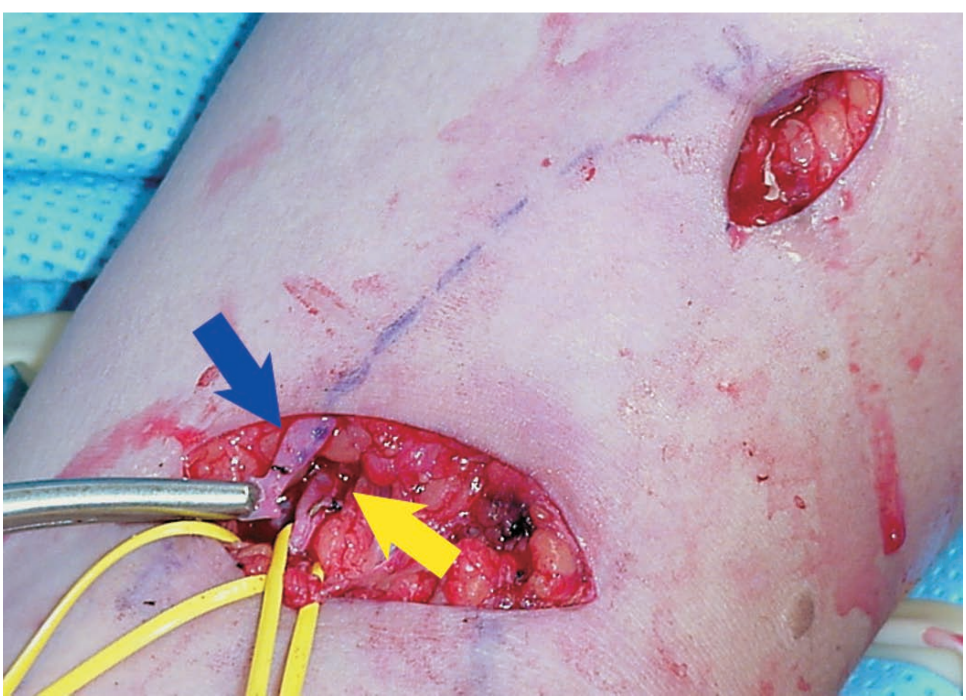


Figure 2.11

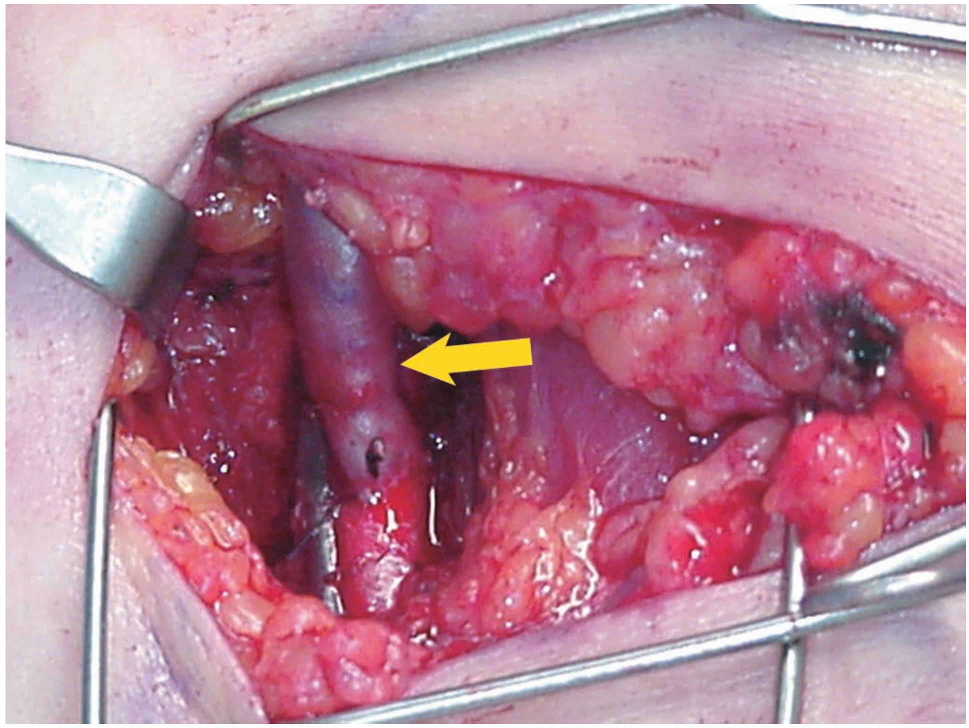
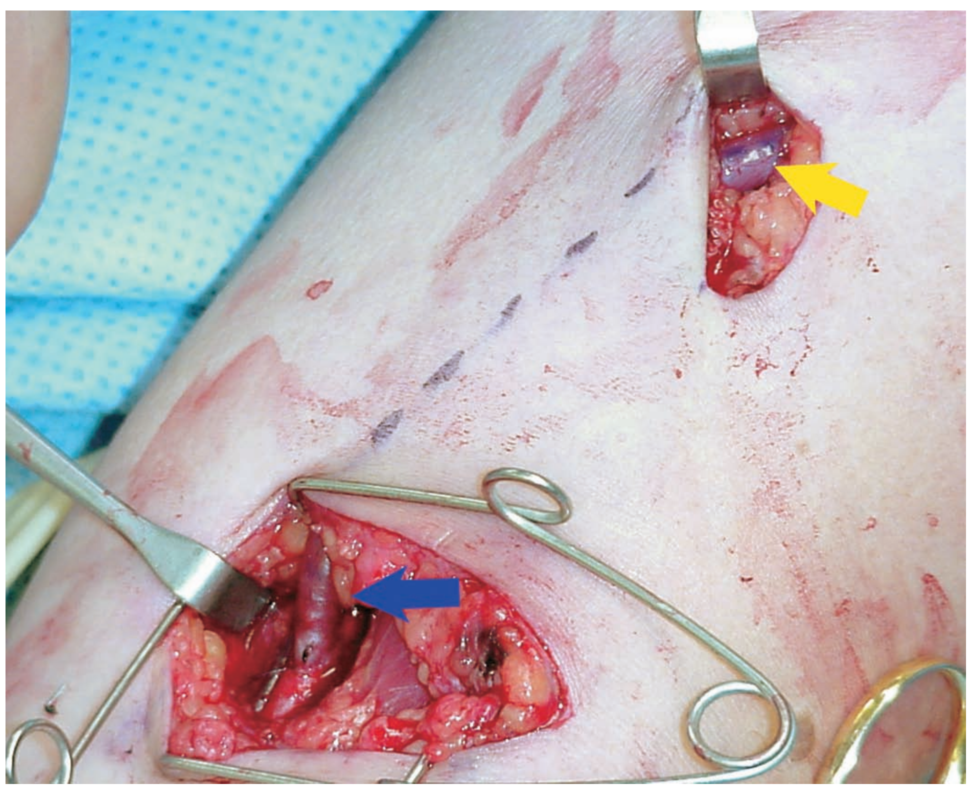


Figure 2.12

7. An end-to-side anastomosis (yellow arrow) is created between the cephalic vein and the brachial artery (Figure 2.12).

8. The arterialized vein is then inspected carefully through both incisions (blue and yellow arrows) to ensure that there is no twisting of the vein and to document that there is good flow (Figure 2.13).



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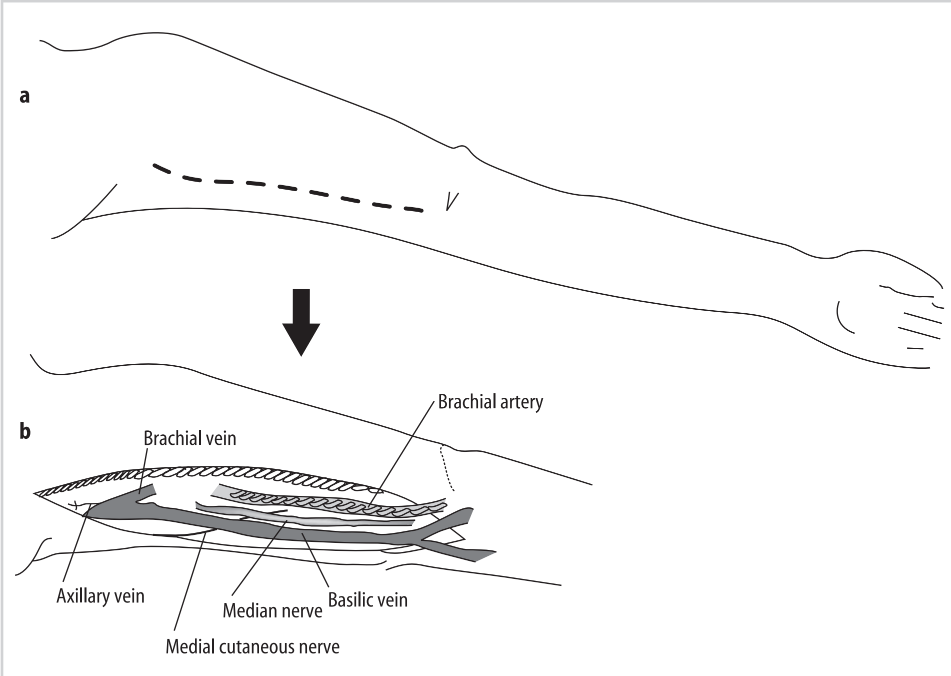

Figure 2.14

c) Basilic Vein Transposition

As the basilic vein in the upper arm runs deep to the fascia, it is protected from trauma related to venepuncture. It may be transposed to a more superficial location for dialysis access. This is a suitable option when the cephalic vein is inadequate for fistula creation. The primary patency for this fistula is about 60% to 70% and the long-term patency is similar to that of a graft.

1. The procedure can be performed with a general anesthetic or local anesthetic with sedation, though the former is preferred due to the extensive dissection involved. The whole arm is prepped, including the axilla. The incision is begun at the antecubital crease in a vertical fashion just medial to the brachial artery pulse (Figure 2.14a). The incision is carried through the subcutaneous tissue; the fascia is incised and the brachial artery exposed. The median nerve (Figure 2.15, green arrow) lies medial to the brachial artery (yellow arrow) at this location and should be identified and preserved (Figure 2.14b). Proceeding slightly more medial and still deep to the fascia, the basilic vein (blue arrow) is visualized and traced proximally, all the way to its junction with the axillary vein (Figure 2.15). At some point, usually in the proximal third of the arm, the medial

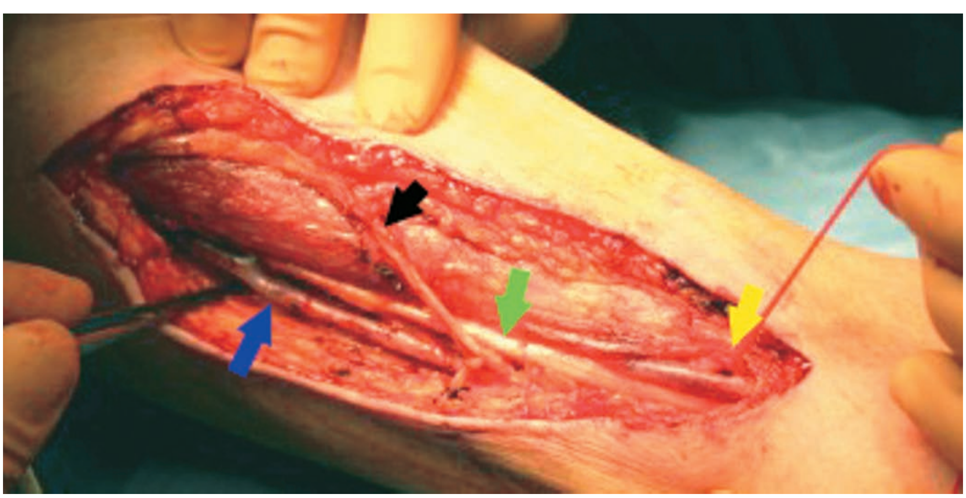

Figure 2.15

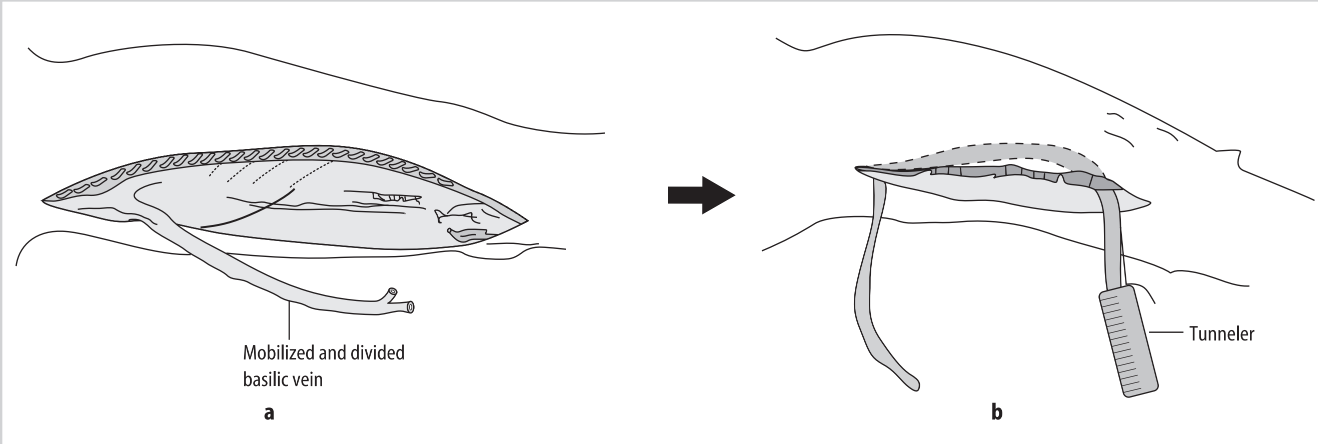

Figure 2.16

cutaneous nerve (black arrow) is encountered. This nerve usually crosses superficial to the basilic vein and, if injured, can result in numbness over the medial aspect of the arm.

2. Once the basilic vein is fully mobilized and all its branches ligated, it is divided as far distal in the arm as possible and brought superficial to the medial cutaneous nerve (Figure 2.16a). If there is adequate length, the vein can be tunneled in a more lateral, subcutaneous location (Figure 2.16b). Alternatively, a lateral flap can be created subcutaneously as a "pocket" for the vein.

3. Proximal and distal control of the brachial artery is obtained and the patient is given heparin. A 6- to 7-mm arteriotomy is then made and an end-to-side anastomosis between the basilic vein and the brachial artery is constructed using fine, nonabsorbable monofilament suture (Figure 2.17a). Clamps are then released and flow estab-

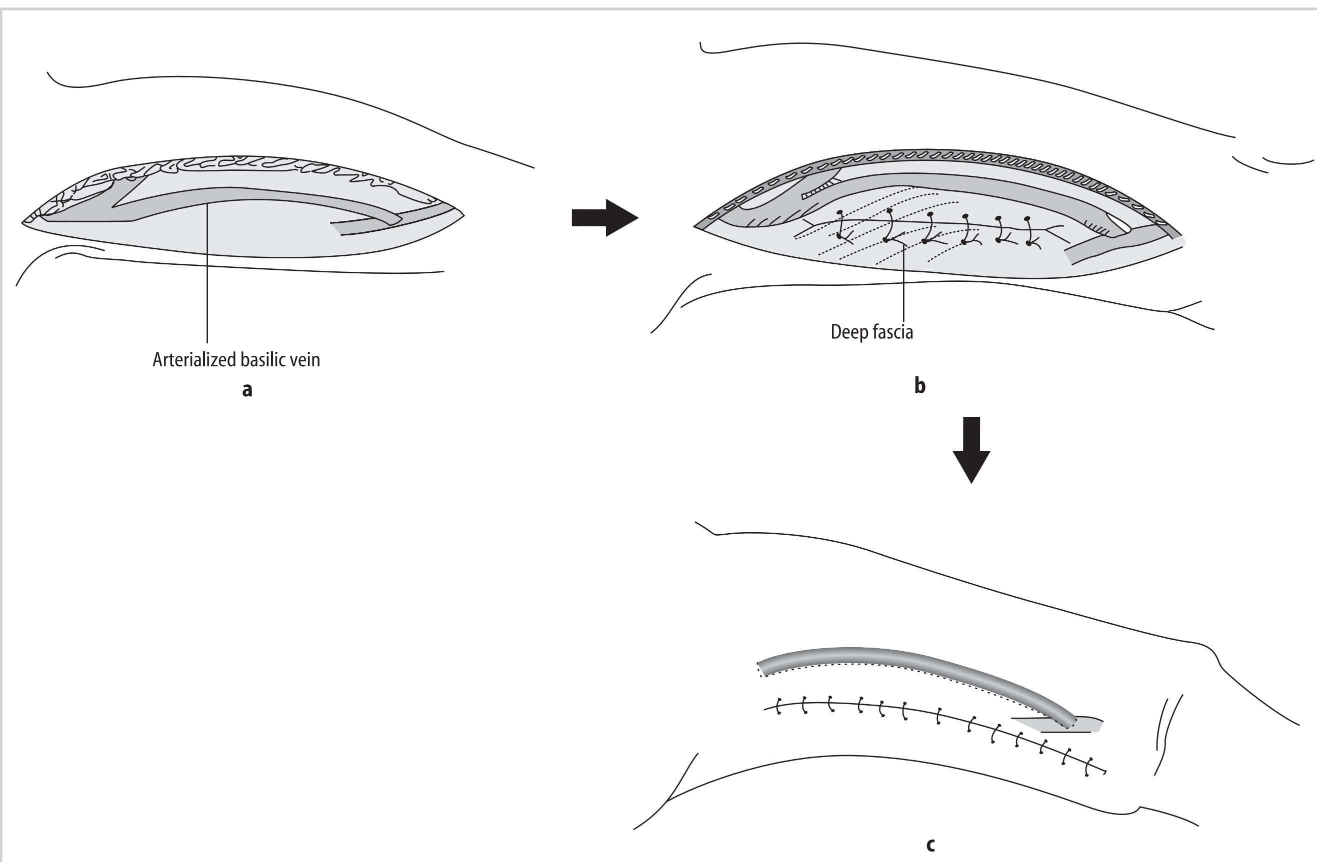

Figure 2.17

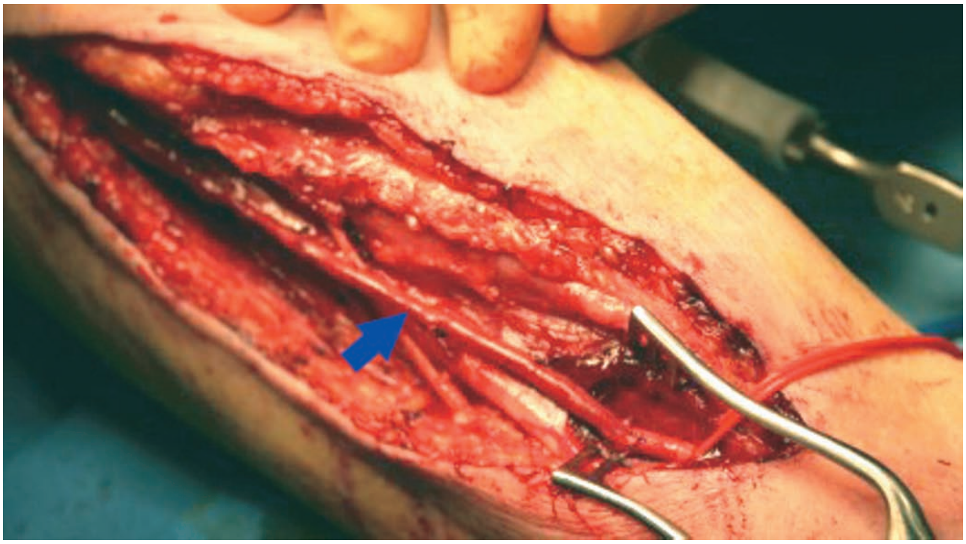

Figure 2.18

lished in the arterialized basilic vein (Figure 2.18). The deep fascia is then closed with interrupted, absorbable sutures, keeping the basilic vein superficial to the fascia (Figures 2.17b and 2.19). The basilic vein is positioned in the subcutaneous pocket, thereby relocating it in a more lateral and more superficial position (Figure 2.17c).

It generally takes about 12 weeks before the arterialized basilic vein is ready for cannulation. Some surgeons prefer a two-stage procedure for basilic vein transposition. At the first stage, the distal vein is anastomosed to the brachial artery without mobilization. The vein is then brought to a more superficial position several weeks later. The proponents of this approach feel that delayed mobilization results in less damage to the vessel wall and a better chance of maturation.

d) Forearm Loop Arteriovenous Graft

Arteriovenous (AV) grafts are reserved for patients who do not have a suitable vein for primary fistula creation. Most commonly employed grafts are made out of polytetrafluoroethylene (PTFE). The preoperative assessment is essentially the same as for fistulas. The primary patency of PTFE grafts is in the 70% to 80% range.

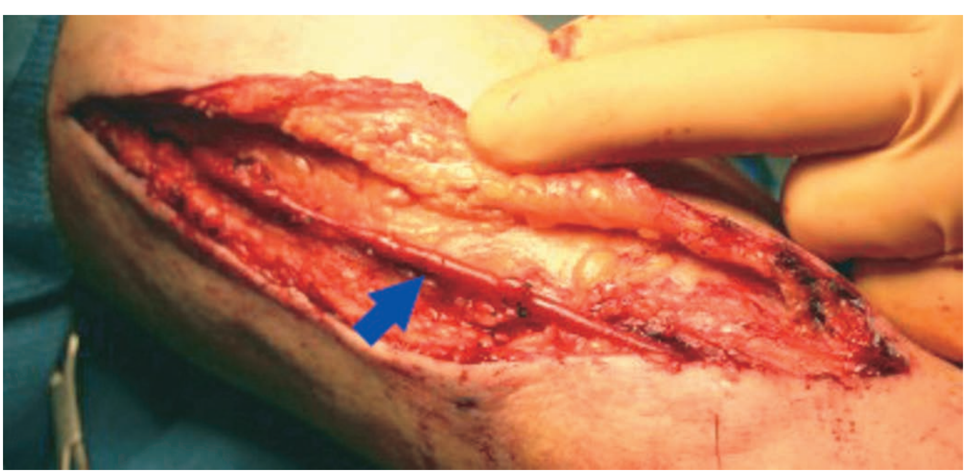

Figure 2.19

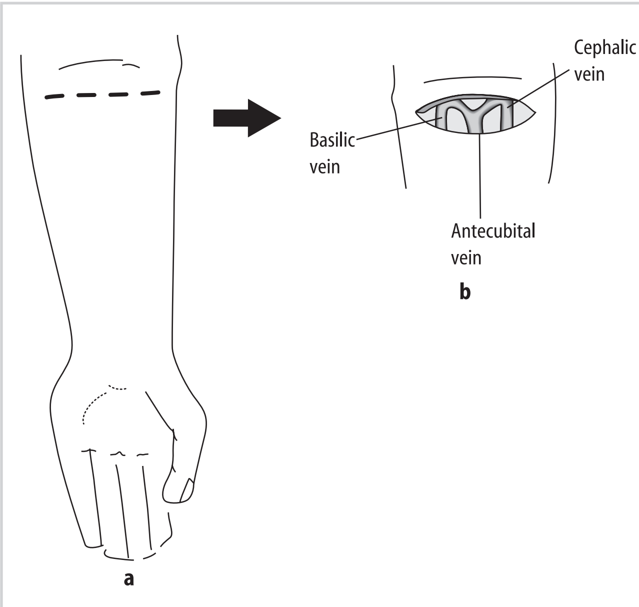

Figure 2.20

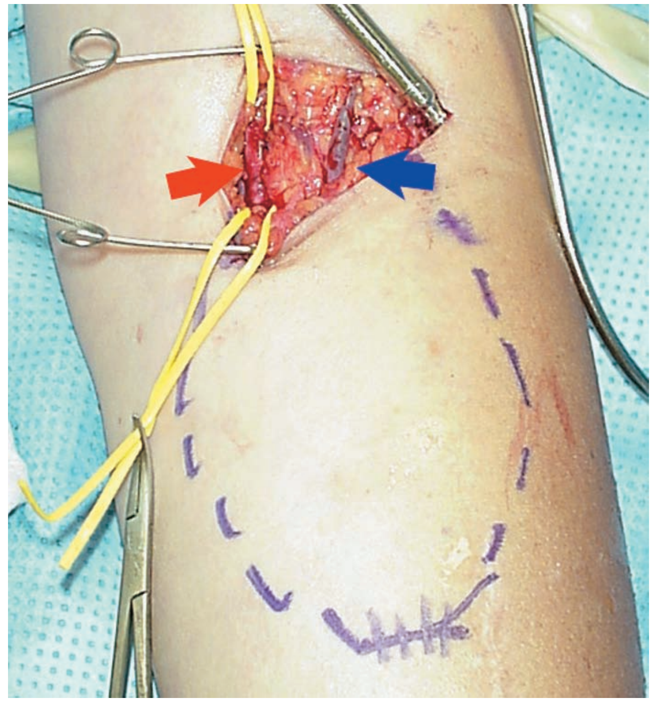

Figure 2.22

1. The procedure is usually performed under a local anesthetic with sedation. Preoperative antibiotics are utilized. A transverse incision is fashioned below the antecubital crease (Figure 2.20a). The antecubital, cephalic, or basilic veins may be exposed in the subcutaneous layer (Figure 2.20b). Any one of these veins can be used for outflow. If these are not suitable, the graft can be drained into the deep brachial vein.

2. If a suitable superficial vein is identified, it is gently looped and preserved. The bicipital aponeurosis is then opened (Figure 2.21a). The brachial artery (red arrow), with its concomitant veins can be exposed deep to the aponeurosis (Figures 2.21b and 2.22). Care must be taken to avoid injury to the median nerve, which courses slightly deeper and medial to the artery.

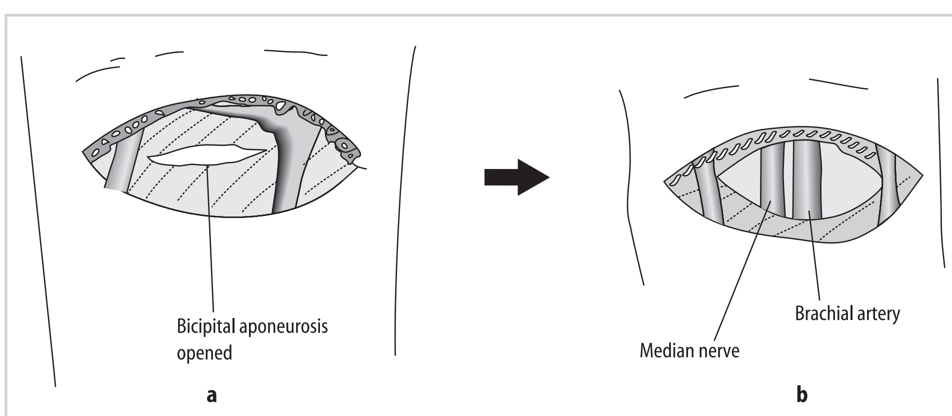

Figure 2.21

3. A tunnel in a loop configuration is then created. A counterincision is made in the middle of the arm, and a tunneling device is used to pass a PTFE graft, usually 6 mm in diameter, in a loop configuration (Figure 2.23).

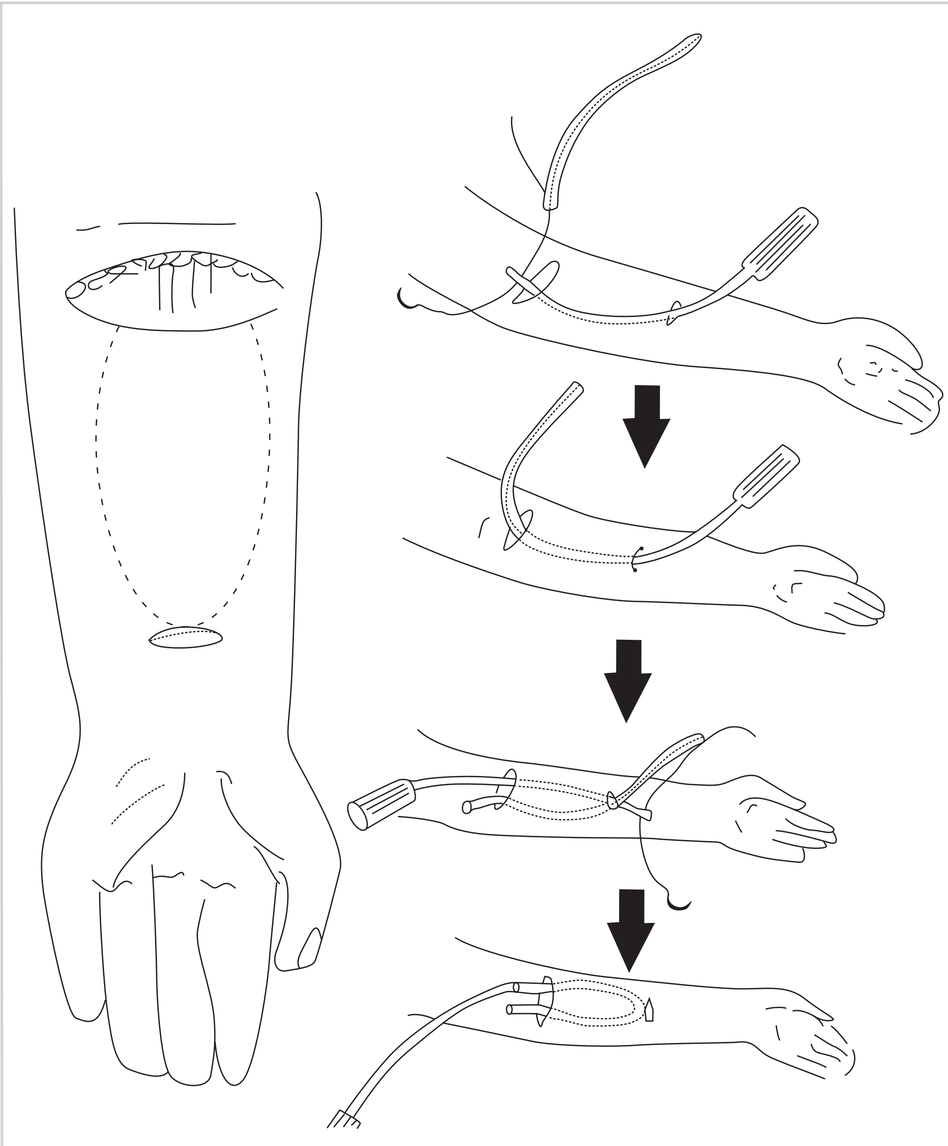

Figure 2.23

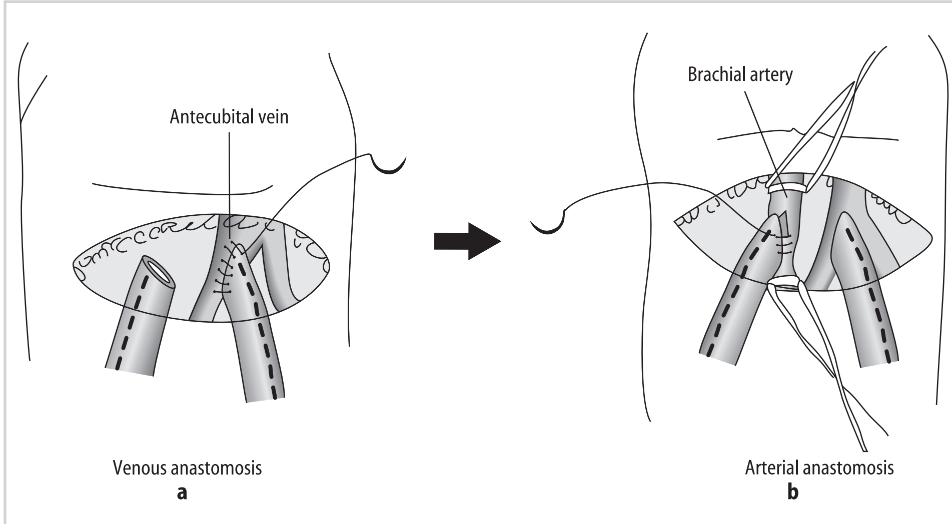

Figure 2.24

4. Once the graft has been tunneled, the patient can be heparinized. The arterial and venous anastomosis are performed, both in an end-to-side fashion. For the venous end, the graft can be cut at a bias to increase the diameter of the anastomosis and decrease the chances of venous stenosis (Figure 2.24a). For the arterial end, large anastomoses are avoided to decrease the chance of developing steal syndrome (Figure 2.24b).

5. The skin is closed over the completed anastomosis (Figure 2.25). It is unnecessary to close the deep fascia. The radial artery pulse is checked prior to completing the operation. Another option for a forearm graft is to place a straight graft with inflow from the radial artery at the wrist and outflow to one of the veins in the antecubital fossa.

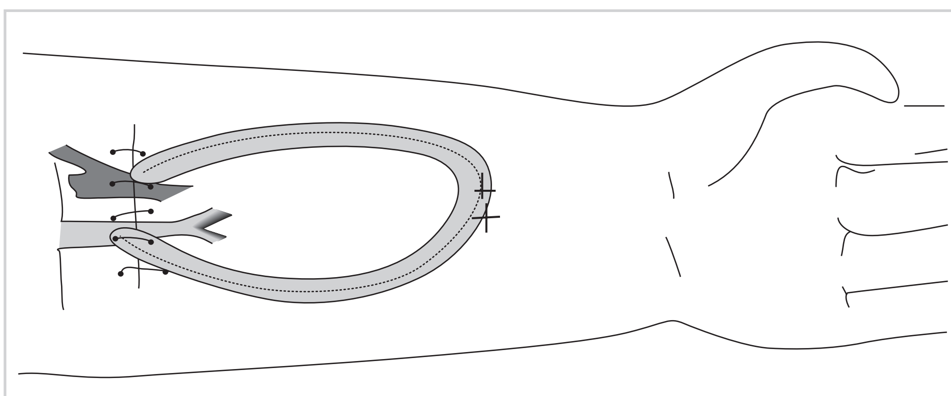

Figure 2.25

e) Upper Arm Arteriovenous Graft

An upper arm or brachial artery to axillary vein graft is possible in most patients, provided there is no central stenosis and no arterial disease. The early patency is excellent with a failure rate of only 0% to 3%. However, complications associated with the use of prosthetic material are inherent in this procedure, such as thrombosis and infection.

1. The preoperative assessment is as already described. The procedure is performed under local or general anesthesia. The whole arm including the axilla is prepped. The brachial artery can be exposed above the antecubital crease through a transverse incision. The axillary vein is usually exposed through a vertical or transverse incision made in the axilla (Figure 2.26a, c). The axillary incision is continued through the subcutaneous tissue and the fascia is opened. The axillary vein can be readily exposed or, alternatively, the brachial vein or basilic vein can be exposed more distally (Figure 2.26b). These two vessels coalesce to form the axillary vein. Any of these veins, depending on their caliber, may be used for outflow.

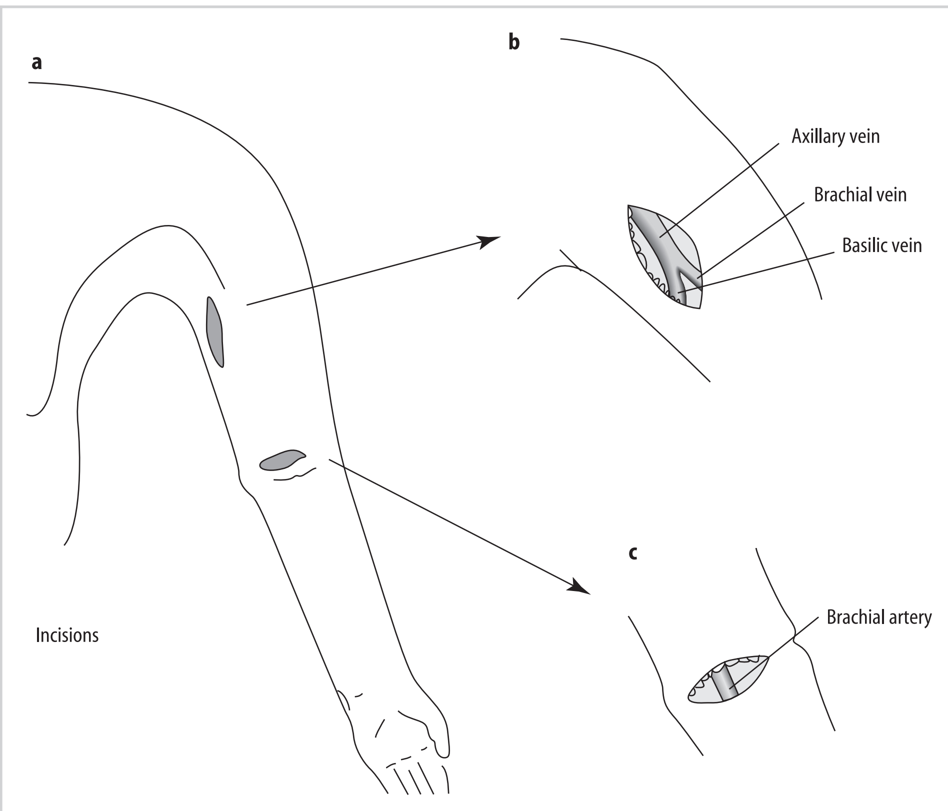

Figure 2.26

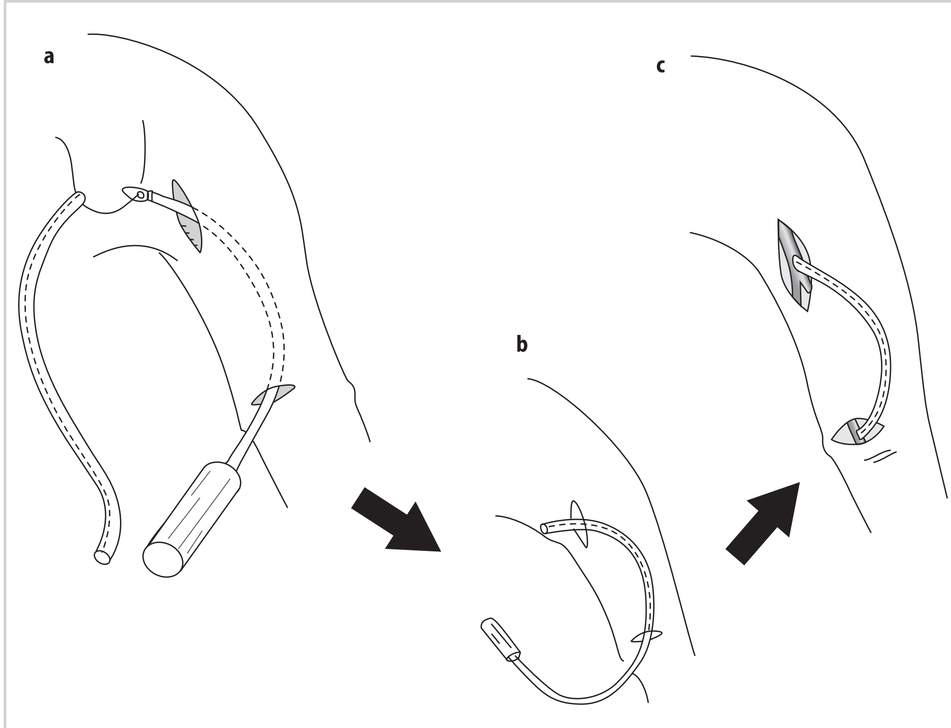

Figure 2.27

2. Using a tunneling device, a 6-mm PTFE graft is placed subcutaneously between the two incisions (Figure 2.27a, b). The graft should be directed lateral, as this is more comfortable for the patient during dialysis. Once the graft has been tunneled in its location, the patient may be heparinized. The venous end of the graft is cut at a bias to increase the diameter. An end-to-side anastomosis is then performed using a fine, monofilament, nonabsorbable suture. The arterial anastomosis is then made in a similar fashion, limiting the arteriotomy to 6 or 7 mm to avoid steal syndrome. The venous clamps are first released followed by the arterial clamps and flow in the graft established (Figure 2.27c).

f) Lower Extremity Access Procedure

Use of the lower extremity for permanent dialysis access should be limited to those situations in which all options involving the upper extremity have been exhausted or are not possible. These procedures unfortunately have a high risk of failure, poor long-term patency rates, high risk of infection, and poor tolerance by patients. Options include a primary arteriovenous fistula utilizing the saphenous vein as the conduit and the superficial femoral artery as the source of inflow. Alternatively, a prosthetic graft can be used with anastomosis to the femoral artery and saphenous vein.

1. For a primary arteriovenous fistula, the saphenous vein is completely dissected out from its junction with the main femoral vein to a level in the mid to distal thigh (Figure 2.28a). All branches are divided and the distal few centimeters of the vein is completely freed so that it can be brought close to the superficial femoral artery for anastomosis. The vein is ligated and divided distally. The superficial femoral artery is isolated at this level for an adequate length to allow for easy anastomosis. The vein is then brought to lie close to the artery. An end-to-side anastomosis is fashioned (Figure 2.28b).

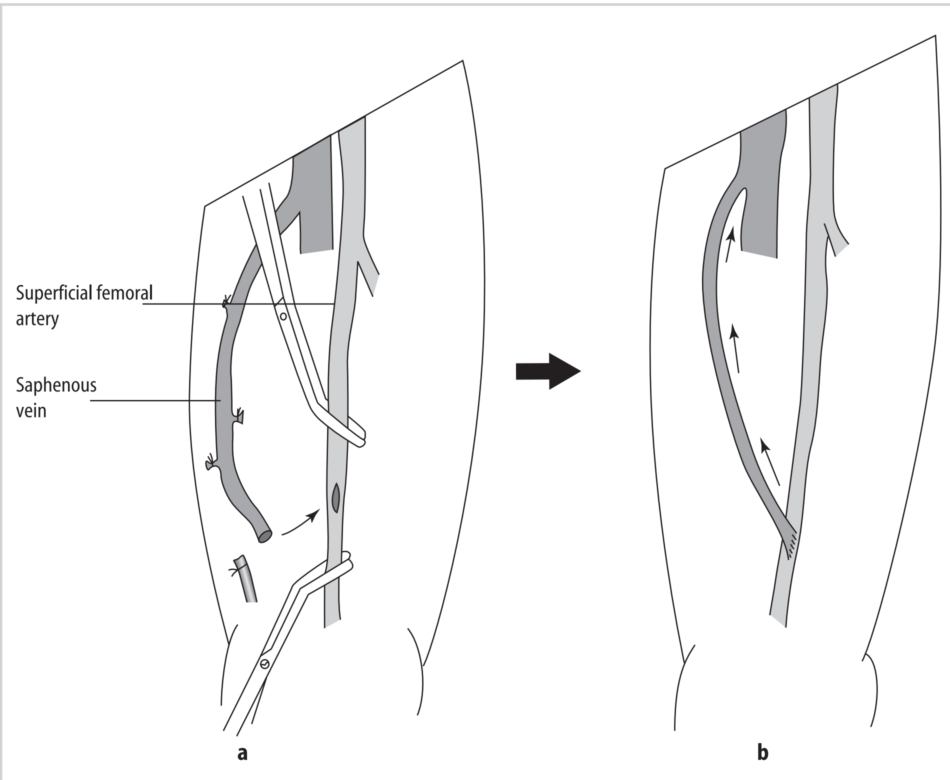

Figure 2.28

2. If the saphenous vein is not of useable quality for an adequate length, then a prosthetic graft can be used. A horizontal or vertical incision is made in the femoral region, directly over where the saphenous vein likely enters the main femoral vein. The artery, which lies just lateral to the femoral vein, is similarly dissected out. The graft is brought through a tunnel, similar to as with a looped graft procedure in the forearm. The ends of the graft are anastomosed to the corresponding artery and vein (Figures 2.29 and 2.30).

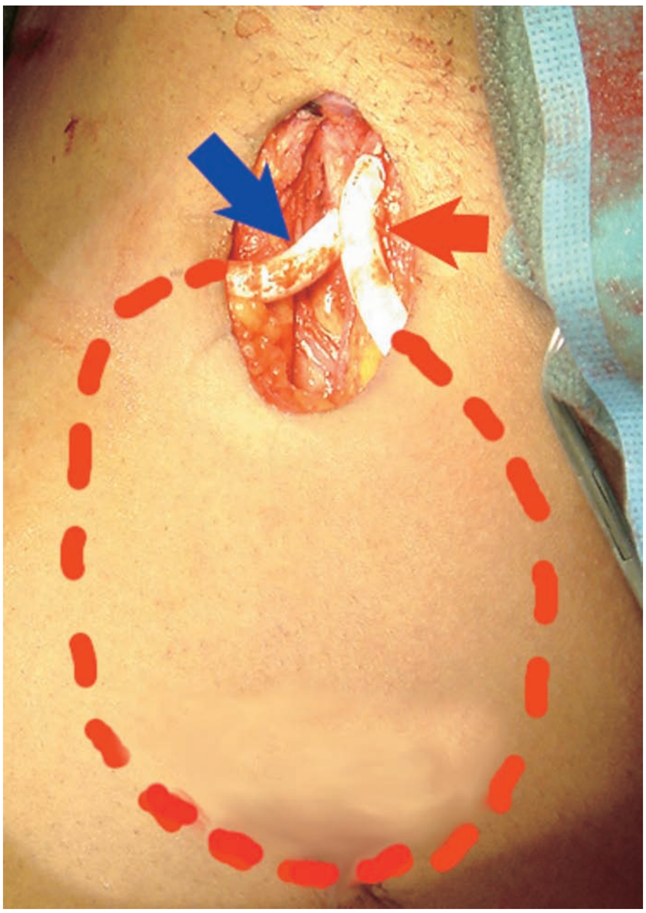

Figure 2.29

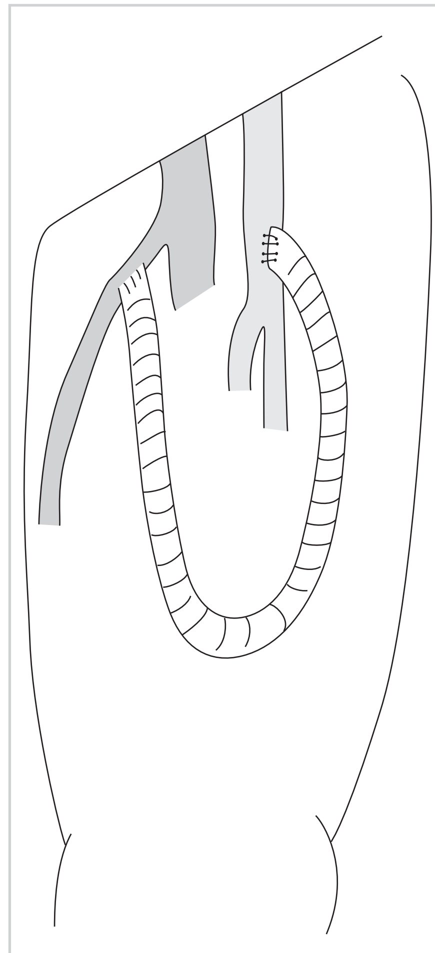

Figure 2.30

Peritoneal Dialysis

Peritoneal dialysis has been in wide usage since the 1960s. For some patients it is an effective means of renal replacement therapy. Several modalities of peritoneal dialysis are now available, but the principle remains the same – fluid and solutes are exchanged via the peritoneum.

As with hemodialysis, careful preoperative planning is required. Peritoneal dialysis may not be a viable option in patients with multiple prior abdominal surgeries as intraabdominal adhesions may preclude effective exchange of the dialysate. The patient must be competent enough to manage the machine and catheter at home. It is a useful option in patients who have difficult vascular access.

Peritoneal Dialysis Catheter Placement

a) Open Technique

In 1968, Tenckhoff developed a silicone catheter that is still used for peritoneal dialysis. Several modifications of this catheter are currently available. Most of the catheters have two Dacron cuffs, one that is implanted just above the peritoneum and the other in a subcutaneous location. Both these cuffs create an inflammatory reaction with subsequent fibrosis and adhesion, preventing bacterial ingrowth from the skin.

1. Typically, either a vertical or transverse incision is made in a paramedian location below the umbilicus (Figure 2.31). If the patient is a renal transplant candidate, the incision should be made on the left, saving the right side for the kidney.

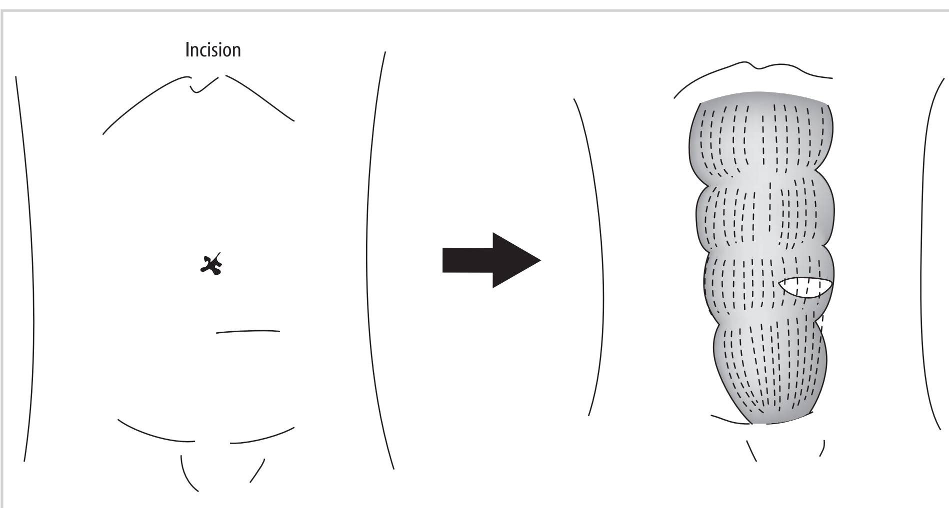

Figure 2.31

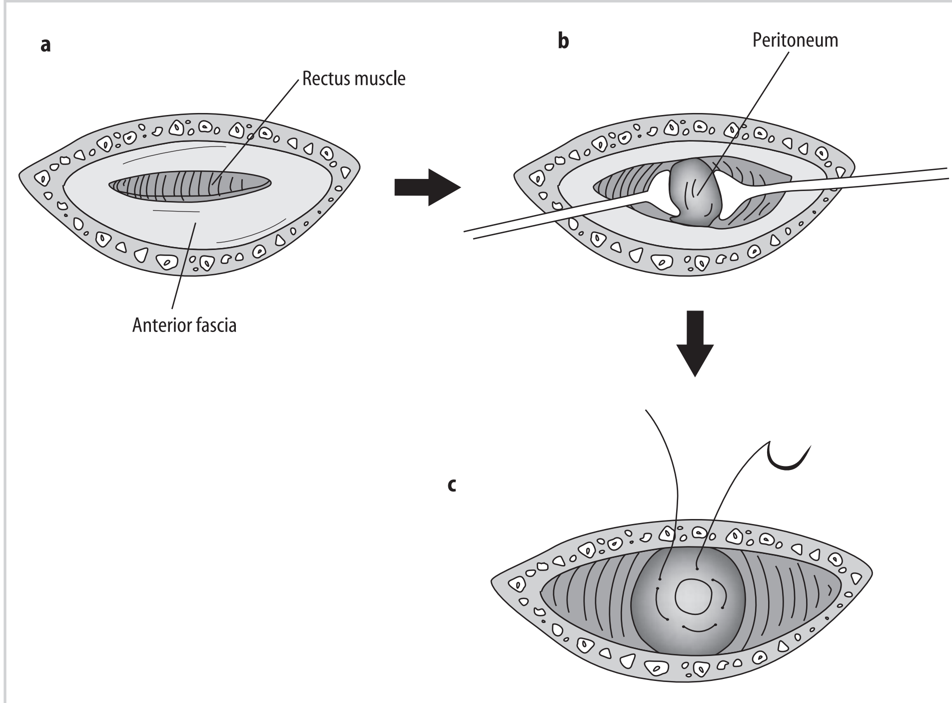

Figure 2.32

2. The incision is carried through the subcutaneous tissue and the anterior rectus sheath incised transversely (Figure 2.32a). The fibers of the rectus muscle are then split bluntly to expose the transversalis fascia and peritoneum (Figure 2.32b). An opening is made in the peritoneum and a purse-string suture placed around the opening (Figure 2.32c).

3. The catheter is then flushed and threaded over an inserting stylet. The catheter (Figure 2.33a) can then be gently fed through the peritoneal opening into the peritoneal cavity, directing it caudad (Figure 2.33b). Care must be taken to avoid injury to underlying viscera during this maneuver. The purse-string suture is tied, securing the peritoneum around the catheter.

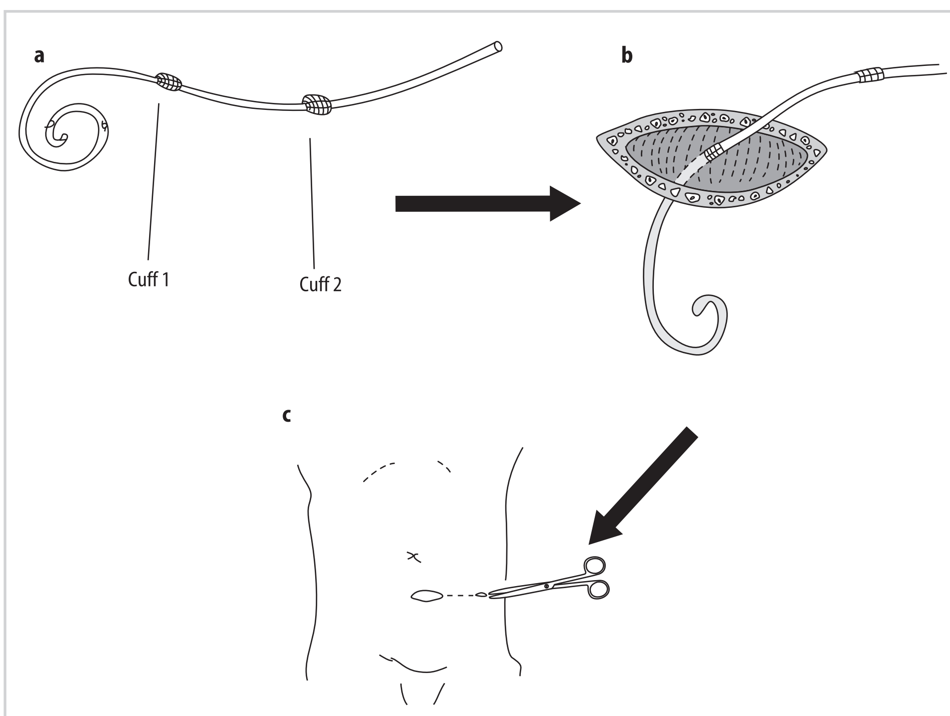

Figure 2.33

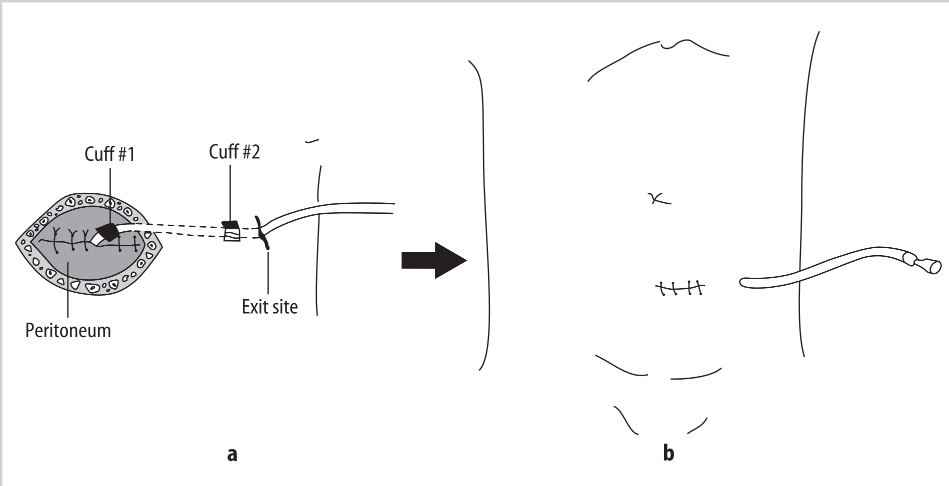

Figure 2.34

4. The first cuff is seated above the peritoneum within the body of the rectus muscle. Part of the suture may be used to directly transfix the Dacron cuff. A lateral tunnel is then created in a subcutaneous space and a small, sharp instrument passed through the tunnel into the original incision (Figure 2.33c); the free end of the catheter is grasped and pulled through. The anterior rectus sheath is then closed with nonabsorbable sutures. The second Dacron cuff is seated 1 or 2 cm away from the skin exit site to prevent erosion through the skin (Figure 2.34a). It is usually not necessary to suture the catheter to the skin. In fact, this may lead to irritation and infection of the catheter site. The skin incision is closed in standard fashion (Figure 2.34b). Prior to leaving the operating room, the catheter is tested by instilling it with saline solution and then checking for drainage by placing the catheter in a dependent position.

b) Laparoscopic Technique

The advantage of the laparoscopic method is that the catheter can be placed under direct visualization, thereby reducing the risk of visceral injury and optimizing placement. Also, with this technique, the catheter may be used right away; the open technique requires a 1 to 2-week wait. The disadvantage is that a general anesthetic is required.

1. The whole abdomen is prepped. Usually two 5-mm trocars are adequate (Figure 2.35a). Some surgeons prefer a third port as well. A 5-mm port is placed in the supraumbilical area either using the open technique or with a closed technique using a Veress needle. Pneumoperitoneum is established with CO_2 insufflation. A second 5-mm port is then placed in a paramedian position below the umbilicus. The peritoneal cavity is carefully inspected for any adhesions or other abnormalities. Adhesiolysis is performed if needed. The Silastic peritoneal dialysis catheter is then threaded over its thin inserting stylet (Figure 2.35b). The 5-mm port in the left paramedian area is then removed and the catheter with stylet is inserted through this opening under direct laparoscopic visualization (Figure 2.35c). The stylet and catheter are carefully advanced toward the suprapubic area and the catheter threaded into the peritoneal cavity (Figure 2.35d). The catheter is pushed into the abdomen until the Dacron cuff is visible. This is then seated

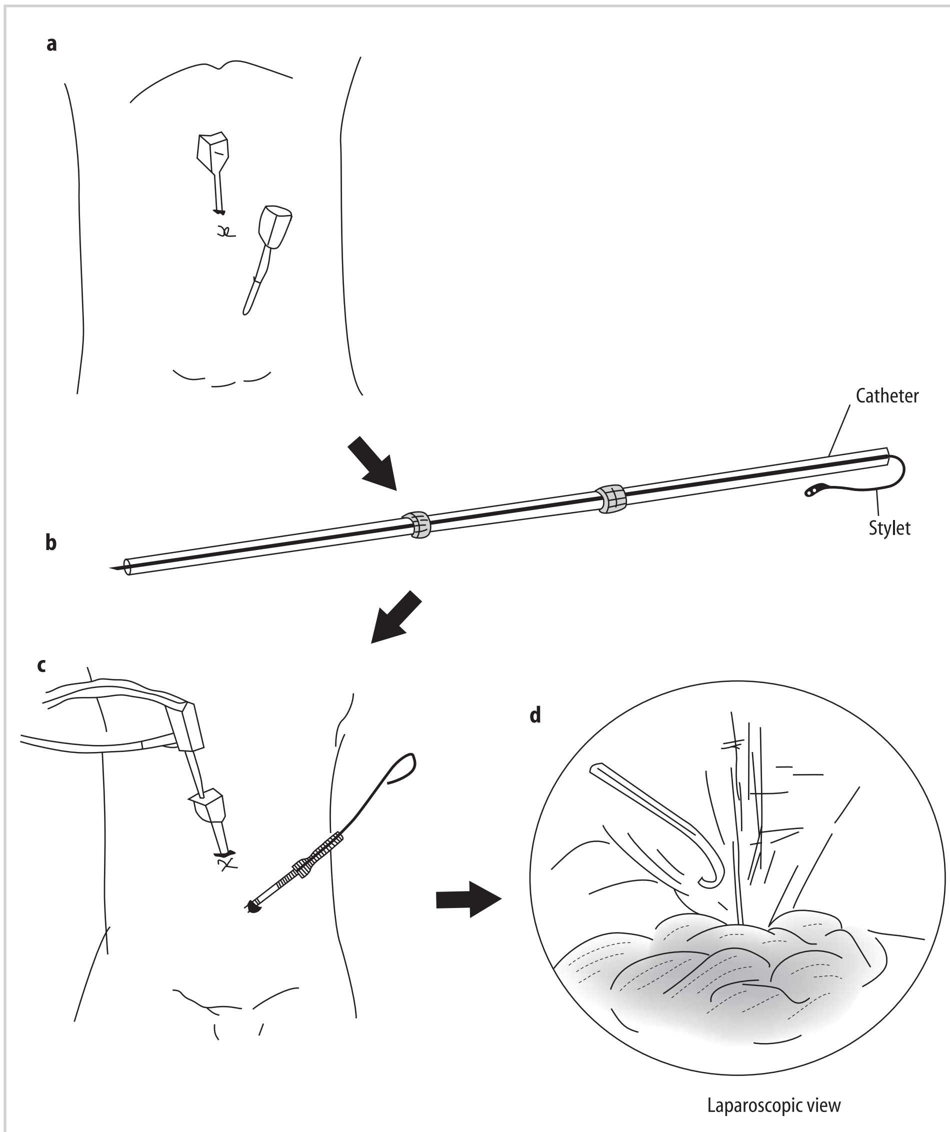

Figure 2.35

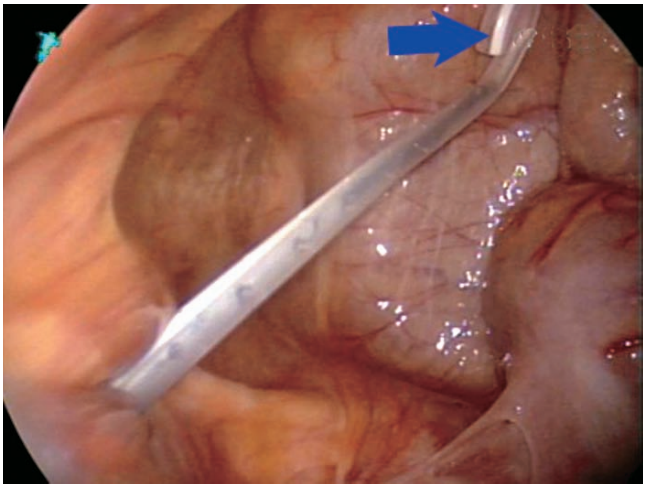

Figure 2.36

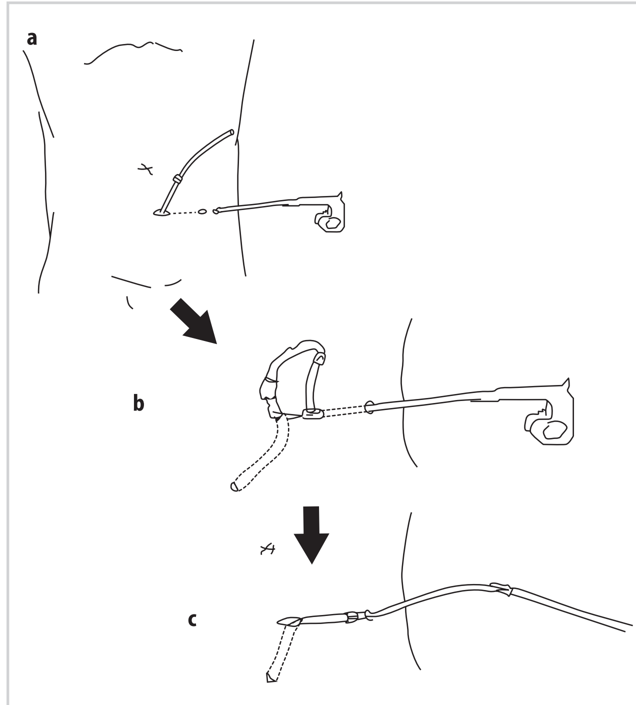

Figure 2.37

just above the peritoneum. The stylet is then completely withdrawn leaving the catheter in place, with its tip directed into the pelvis (blue arrow) (Figure 2.36).

2. A small incision is then created laterally for the catheter exit site. Using a long grasping instrument, a subcutaneous tunnel is created between this incision and the paramedian incision (Figure 2.37a). The end of the catheter is grasped and pulled out, situating the second cuff about 1 or 2 cm away from the skin exit site (Figure 2.37b). The subcutaneous tissue and skin are closed at the paramedian incision but no deeper stitches are necessary. The pneumoperitoneum is released and catheter function is tested by instilling 500 cc to 1 L of normal saline and then letting it flow out by dependent drainage. The initial port site is then closed in standard fashion (Figure 2.37c).

Selected Readings

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